Space Weather Technical Forecast

Issued on Friday, 16 December 2022 at 12:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-class flares (R1-R2 Blackouts) likely from AR3165.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity has been Moderate with occasional M-class flares observed during the past 24 hours, mostly from AR3165 (Ekc/Beta-Gamma-Delta), the largest region, which gave a peak flare of M5.7 observed at 15/2240 UTC. There are six other sunspot regions on the visible disc. Of these AR3163 Eki/Beta Gamma-Delta is the second largest region, a moderately sized spot in the southeast. AR3166 is the third largest with little change in recent hours. The remaining regions on the disc are relatively small, weak and magnetically simple, showing little or no development. No Earth-directed Coronal Mass Ejections are currently in the forecast given available imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR and ACE have been at slow-ambient levels, with a downwards trend from 370 to 320 km/s. Density was below average. The total IMF, Bt, was weak, below 7nT. The north-south component of the IMF, Bz, was weak varying between +6/-6nT. The phi angle was predominantly negative (towards the Sun) throughout. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background to Moderate levels, with peak 177 pfu at 15/1450 UTC. The associated 24-hour fluence decreased through the day, and remained well below Active (1e8 integrated pfu). Observed fluence at 16/0000 UTC was 2.44e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Moderate, especially for days 1 and 2 (16th and 17th) before AR3165 rotates off the visible disc, with further M-flares. There is a slight chance of reaching High levels, with the maximum peak flare potentially reaching X-class. New active regions are will probably rotate onto the visible disc over the next few days.

Solar Wind / Geomagnetic Activity: There are currently no Earth-directed CMEs, although there is a slight chance of a glancing interaction on day 3 (18th) due to the filament eruption CME observed on the 14th, although this is expected to mostly pass to the south of Earth. Solar winds at slow-ambient levels, may rise to Slightly Elevated around day 3 (18th), when the arrival of fast winds from CH54 could impact Earth. The predicted strength and timing of any enhancement is low confidence. Quiet (Kp 0-2) geomagnetic activity is expected, with a chance of becoming Unsettled to Active (Kp 3-4) around day 3 (18th).

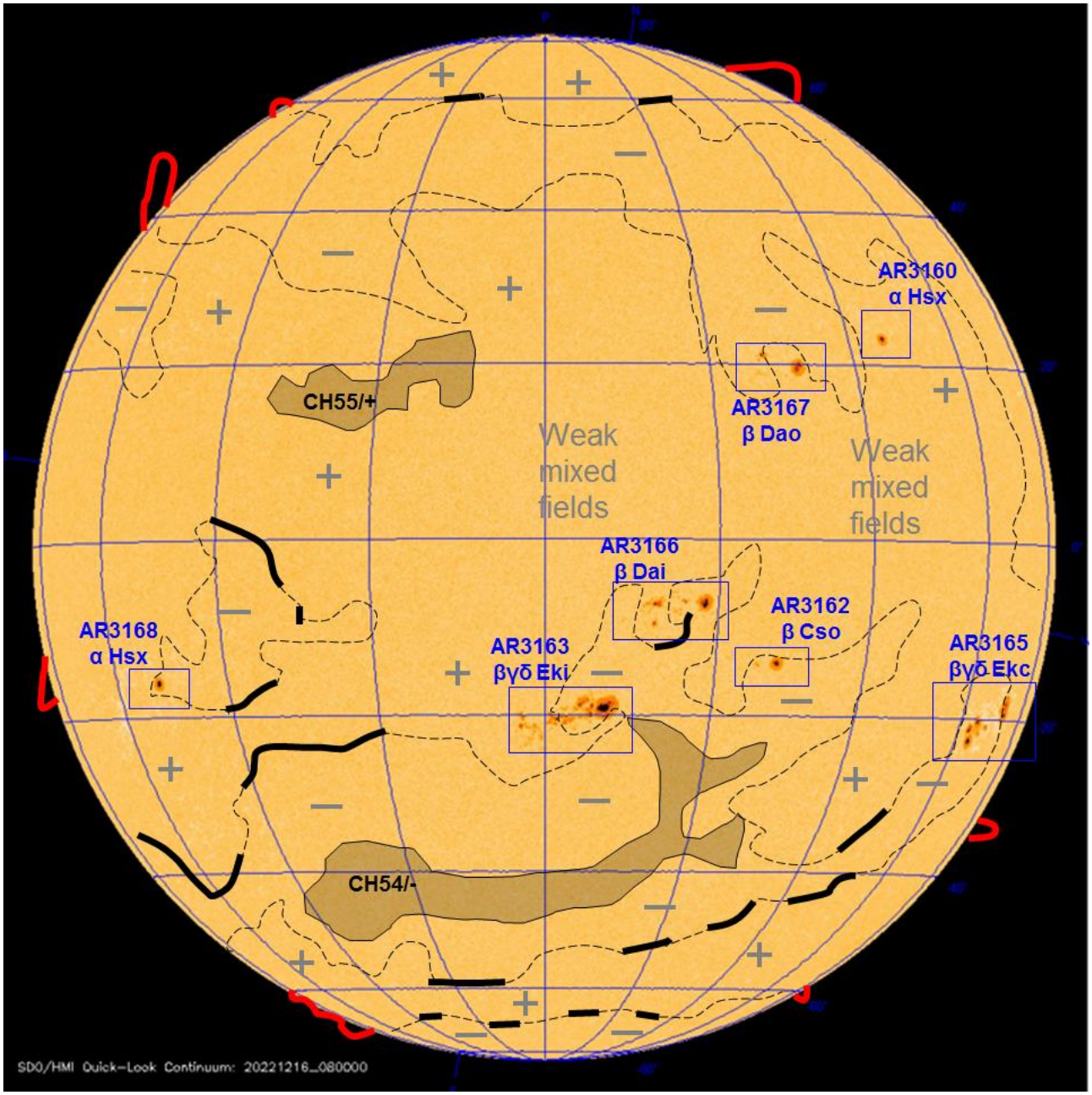
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels throughout, although there is chance of rising towards

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

the S1 level with the occurrence of any notable flares. High energy (greater than 2 MeV) electron flux is currently at background to moderate flux levels and expected to persist at these levels. The associated 24 hour fluence is expected to continue well below the Active (1e8 integrated pfu) threshold with a mostly flat trend anticipated.

Figure 1. Solar Analysis Valid 0800UTC, 16 December 2022.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

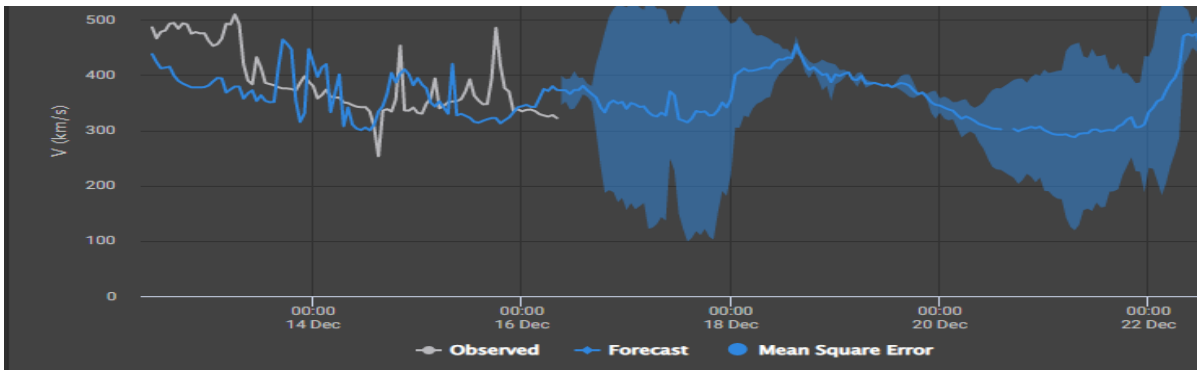
There are currently no Earth-directed CMEs. The filament lift off from the southwest around 14/0300 UTC has been assessed as missing Earth, but brings a slight chance of glancing impacts during day 3 (18th).
Solar winds are expected to be at slow-ambient levels for the next couple of days and the next enhancement arriving around day 3 (18th) from CH54/- currently moving westwards across the southeast disc quadrant. This is a persistent feature, but reduced in size and northward extent compared to the previous rotation. However, its leading (western) edge is in a similar location, suggesting the timing of any enhancement that occurs is likely to follow the 27-day persistence, with solar wind speeds probably reaching slightly elevated around day 3 (18th), reaching up to 450 km/s. This arrival is not obvious in current MOSWOC ENLIL, therefore producing low confidence for a significant enhancement or any subsequent geomagnetic activity. Quiet geomagnetic activity is expected, with a chance of becoming Unsettled to Active, with a very slight chance of G1 Minor Storms day 3 (18th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1530	Partial	Filament eruption at 14/0300 UTC	SW	410	18/0800	Low confidence of a glancing blow

Figure 2: Met Office Solar Winds Prediction Model (SWPM) showing mainly slow-ambient levels.



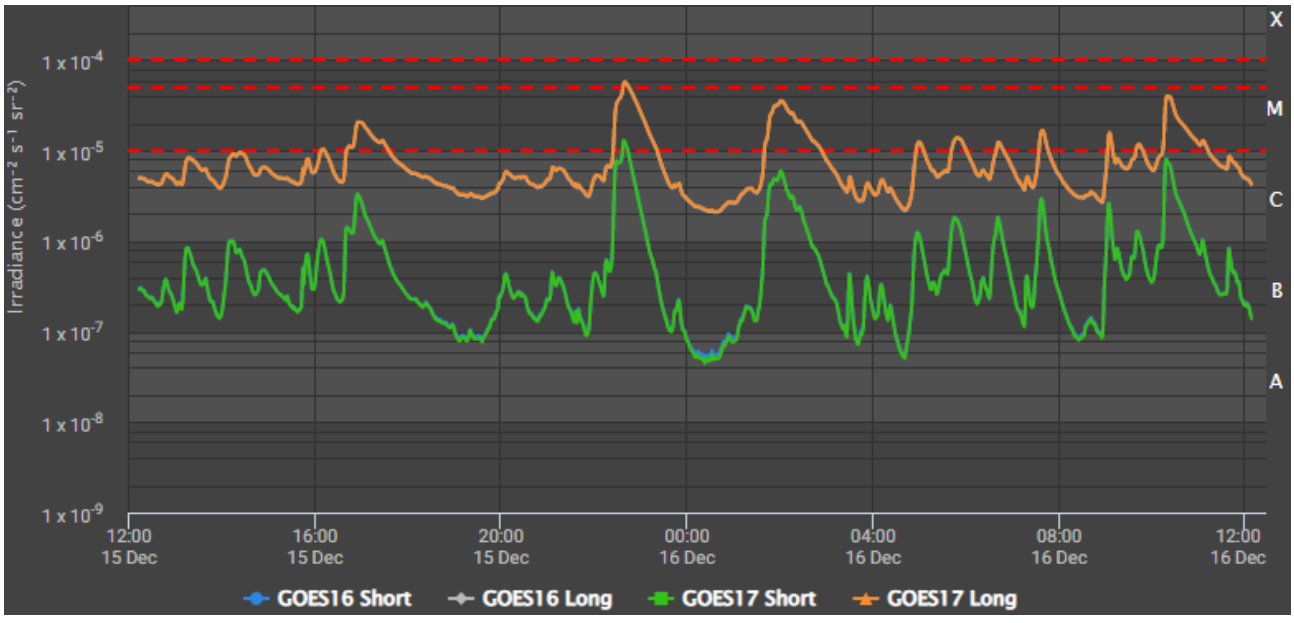
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
There are seven sunspot regions, the most active, and largest, being AR3165. This is classified as Ekc/beta-gamma-delta with an asymmetric large leader spot, and very complex magnetic field. AR3163 is similarly large with a classification Eki/beta-gamma-delta with a delta spot now visible. AR3166 is the third largest with little change in recent hours. The remaining regions on the disc are relatively small, weak and magnetically simple, showing little or no development. Solar Activity has been Moderate with occasional M-flares over the last 24 hours from AR3165, the largest a M5.7 peaking at 15/2240 UTC. Solar activity is likely to continue at Moderate levels, with further M-class flares likely from AR3165 but also possibly from AR3163. There is a slight chance of activity increasing to High with an isolated X-flare, especially in the first two days of the forecast period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	40	40
Very Active	R3 to R5 X Class	No	15	15	5	5

Figure 3:X-ray flux at GEO with numerous M-class flares in recent hours.



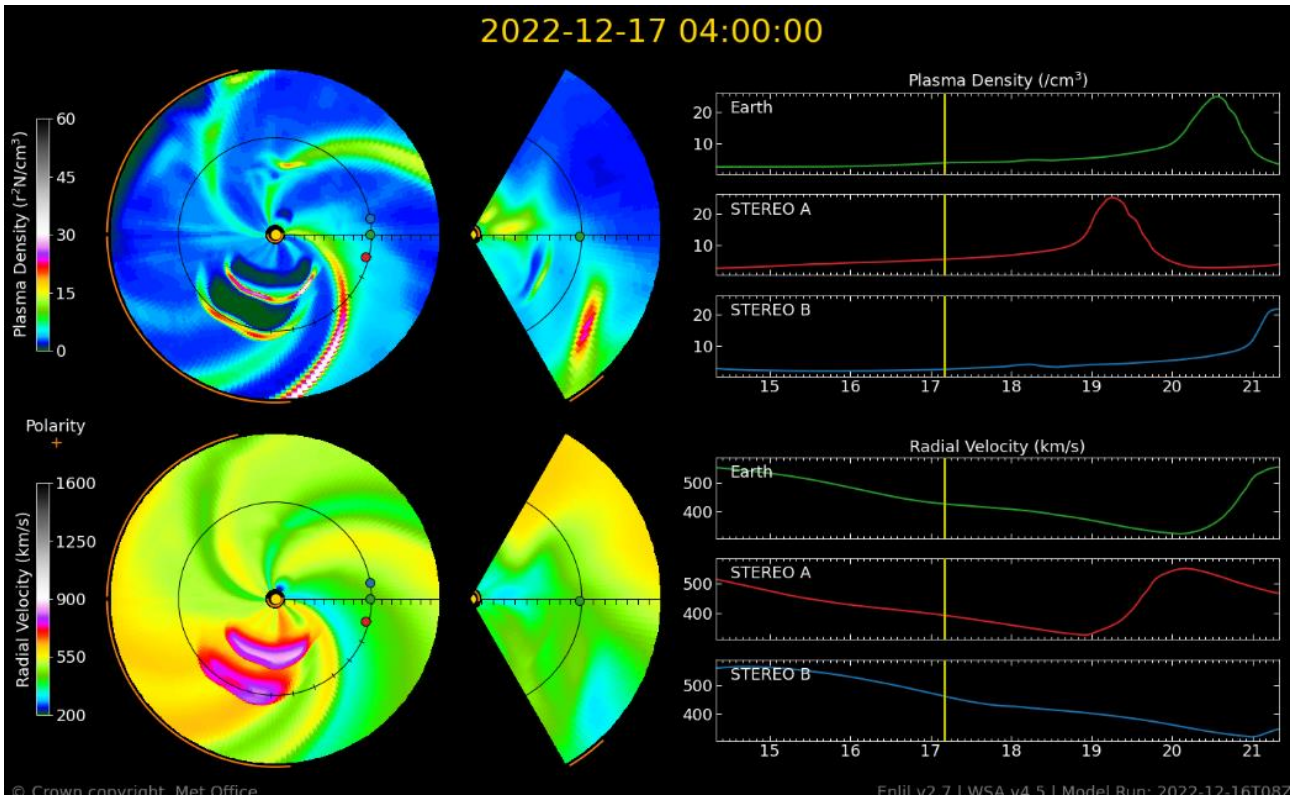
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) as measured by GOES-16 is expected to remain at background levels throughout. However the frequent M-flaring of AR3165 in the southwest, along with the number of other sunspots on the disc, brings a slight chance of flux levels rising, and potentially exceeding the S1 Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest ENLIL model output showing various CMEs, mainly eastwards (wrt Earth) directed and probably not towards Earth.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux, as observed by GOES-16, is currently varying between Background and Moderate levels. With no significant solar wind enhancements expected, these electron flux levels are expected to persist through the period. The associated 24 hour fluence is forecast to persist below the active threshold (1e8 integrated pfu). This is supported by REFM output which is currently giving realistic guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux and Met Office REFM output showing little activity.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.